APPENDIX A: USE OF DECOYS TO ALTER ASPECTS OF COMMON MURRE REPRODUCTION

Decoys have been used to alter the behavior of many gregarious species (Kress 1998). In particular, decoys have a long tradition in waterfowl hunting, and have been used to lure migrating waterfowl within the range of hidden hunters (Greenwood et.al., 1986, Harvey et. al., 1995). Decoys have also been used to examine a range of hypotheses about territoriality and the role of endocrinology in birds (e.g., Romero et. al., 1997). In both uses, the physical decoy may be accompanied by sound, giving the real birds both visual and auditory input. The implicit assumption is that decoys/recordings are life-like enough that real birds see and respond to them. In fact, some studies show that whereas all decoys elicit some response, the specific type of decoy is important in response strength (Harvey et. al., 1995).

In seabird conservation, decoys have been used under the heading social attraction, or social facilitation (Kress 1998), to lure individuals of gregarious species back to nesting colonies abandoned or extirpated (Kress 1983, Fancher 1984, Kotliar & Burger 1985, Kress & Nettleship 1988). Here, decoys are thought to provide additional social cues over and above the physical cues (e.g., appropriate nesting habitat, adequate food supply) already provided by the environment. Essentially, decoys either jump-start the process which may otherwise take decades (e.g., Kress & Nettleship 1988, Johnson & Castrale 1993), or create an additional social attraction over and above a remnant colony (e.g., Fancher 1984, Blokpoel et. al., 1997, Parker et. al., 2001). More recently, decoys have been used to lure birds from healthy colonies to new locations, out of harm's way (e.g., Short-tailed Albatross on Torishima; Caspian Terns in the lower Columbia River). Thus, decoys are a powerful tool which can be used to "create" new colonies, stabilize existing - albeit faltering - colonies, or relocate healthy colonies.

It has been suggested that decoys alter several aspects of reproduction, beyond simple breeder numbers. Decoys may provide a specific source of attraction which would alter nesting density (e.g., denser nesting adjacent to decoys), synchronize egg laying, or enhance the aggregative behavior of the species. Each of these things should, in turn, contribute to successful breeding, with the proximate goal of raising reproductive success to acceptable levels, and the ultimate goal of pushing lambda above one.

Of course, all of the above assumes that the physical environment and local community interactions are hospitable. That is, while decoys may be successful in attracting birds, ultimate reproductive success and colony growth will depend on whether local conditions are favorable. Thus, in situations where colonies of gregarious seabirds have declined due to unknown causes (rather than known anthropogenic causes), the use of decoys might not be appropriate.

Tatoosh Island is the most stable breeding colony of Common Murres in Washington State, producing fledglings every year since monitoring began in 1990. Population size on Tatoosh (proxied by annual attendance during the breeding season) has declined over the past decade, and breeding success has been predominantly affected by direct and indirect effects of predators, namely Bald Eagles (Parrish et al. 2001). Colonies south of Tatoosh experienced steep declines in attendance in the early 1980s (Wilson 1991) followed by erratic attendance and reproduction throughout the 1980s and 1990s (Wilson, unpub. data). The cause of this decline is unknown, although episodic climate events, such as El Niño and other warm water phenomena have been cited as probable causes (Wilson 1991). However, in other parts of the West Coast, climatic events such as El Niño fail to produce such long-lasting effects (e.g., Bayer 1986), leading to the suspicion that multiple forces may be at work. Moreover, recent foraging data from Tatoosh and Copalis Rocks National Wildlife Refuge suggest that forage fish resources in the vicinity of these colonies is more than adequate to sustain the existing murres and their chicks (see Table 1,3). Alternately, colony numbers may have become so low, or so erratic, that the minimum stable social cues needed to breed may no longer be present, even if the local environment is once again hospitable.

In light of apparently successful colony manipulations in Northern California, where a once large murre colony (Devil's Slide Rock; Parker et. al., 2001) which experienced a range of anthropogenically-mediated population decline, has recently been stabilized and is now increasing, the use of decoys has been suggested to restore southern Washington colonies.

Several questions arise:
(1) What are the principal factors which caused the shift towards instability in the southern Washington colonies? Are they still extant? Are there other factors (e.g., lack of social cues) which might now preclude de novo murre colonization?

(2) Are the factors affecting population growth on Tatoosh the same as those affecting the southern Washington colonies? In other words, does eagle predation and interference play a role?

(3) If the above is true, how might this predator-prey interaction affect the use of decoys as a nesting attractant?

In 1999 through 2001, experiments were run to examine the degree to which altering the physical versus the social environment would affect aspects of reproduction of Common Murres nesting on Tatoosh Island. In this study, we were specifically interested in whether and how decoys would alter murre behavior leading to population-level response (e.g., an increase in nesting area reproductive success). In addition, because prior work had shown that the physical environment, specifically the degree of cover, could alter reproductive success (Parrish & Paine 1996), we were interested in presenting the murres with a set of choices:
(1) Safe versus risky physical environment, as defined by eagle access
(2) Socially enhanced versus plain environment, as defined by the presence or absence of decoys
(3) Interactions between the two conditions

In all three years, the experiment was conducted on an established cliff-top nesting area (TPCT2) at which a long-term blind had been established. The general configuration of the experiment was to secure the area comprised by live salmonberry with a 50cm wide “fenceline” of wooden stakes topped with artificial vegetation. This approach had proved conducive to murre nesting in previous years (e.g., Parrish & Paine 1996). Stakes were arranged such that murres could easily pass through, but eagles could not. Against this physical backdrop, we placed a variable number of decoys, in groups of two or three (Figure A1). In total, 13 sets of decoys were deployed. Data were collected on the nesting density and reproductive success of murres within one meter diameter plots centered on each decoy pair, on random points within the salmonberry and within the open area exclusive of decoys, and on randomly chosen points within the fenceline (where no decoys were placed). No decoys were placed in the open area in 2001.

Over three years, neither decoy presence nor physical structure had a significant effect on nesting density (2 way ANOVA, decoy presence: $F = 0.368$, $P = 0.554$; physical structure: $F = 2.888$, $P = 0.111$; Figure A2). Statistically, nesting density was uniformly high, as murres filled the available space. These data suggest that physical structure is at least as powerful an attractant (at least for a healthy nesting area) as decoys, as there was no difference between nesting density in salmonberry as a function of decoy presence or absence (Figure A2, A versus B). However, these data also suggest that when nesting in the open, murres preferred to nest in association with decoys, rather than without them, although this trend is not statistically significant.

The effect on reproductive success, however, was pronounced (Figure A3). Murres nesting in salmonberry, whether in association with decoys or not, had uniformly higher reproductive success. Murres nesting in the open area, or in the fenceline buffer zone, had low to no reproductive success (2 way ANOVA, decoy presence: $F = 0.034$, $P = 0.857$; physical structure: $F= 22.953$, $P = 0.000$). Decoys not only did not enhance reproductive success, they appeared to decrease success, at least in the open area (Figure A3 A versus B).

This effect is a consequence of eagle pressure. In 1999 and 2000, eagles visited the nesting area (2 and 28% of total observation time, respectively). During each visit, murres nesting in the open area, and in the fenceline buffer zone flushed either off the cliff, or back into the salmonberry. Eagles would spend from minutes to hours patrolling the fenceline. A maximum of 5 eagles were witnessed simultaneously in 2000. In both years, several kills were witnessed (8 in 1999 and 5 in 2000), either of murres caught during the initial landing of the eagle, or of murres attempting to escape to the safety of the water during patrolling bouts. In 2001, eagles rarely visited the island, were never observed on or adjacent to the nesting area, and no kills on the nesting area or signs thereof (e.g., carcasses) were seen. Average annual reproductive success of the nesting area was significantly affected by eagle pressure (measured as an equal weighting of % time present and kills; least squares linear regression, $T = -27.722$, $P = 0.023$; Figure A4).

Essentially, in years when eagles are present, they exert a tremendous pressure on reproductive success. Some of this is direct - eagles eat murres - but much of it is indirect - eagles scare murres (see also Parrish et. al., 2001). In the latter case, murres either lose their eggs to egg predators (if they flush off the nesting area for the safety of the water and fail to immediately return) or the eggs become addled (if eagles remain on the nesting area and murres which have flushed into the salmonberry are prevented from reclaiming their eggs).

How do decoys alter this picture? In years of low eagle pressure (e.g., 2001), decoys can attract murres to low quality sites (e.g., open area). In this case, decoys can act to stabilize and synchronize egg laying. However, in years when eagles are present, these very murres will have made an incorrect decision. At least they will lose their reproductive investment (Figure A3). At most they will lose their lives. In both 1999 and 2000, the majority of witnessed kills and carcasses found were adjacent to decoy pairs in the open area, suggesting that nesting adjacent to a decoy pair could provoke life-threatening consequences. In fact, eagles frequently attacked the decoys, spending up to 1/2 hour at a time attempting to pull the decoys from the rebar stakes on which they were secured. Thus, it is clear that decoys *must* be used with caution in regions were predators, especially eagles, are present, as decoys appear to attract *both* murres and eagles.

These results suggest that wholesale deployment of decoys in physically unprotected open areas may have unintended and deleterious consequences. By contrast, deploying decoys in physically safe zones - here within reinforced vegetation - could prove at least neutral, and at most beneficial. Other types of safe zones might include rock ledges and crevices at which eagles are unable to land.

This experiment suggests that in the Pacific Northwest, where eagle populations are higher than in other West Coastal areas, social attraction techniques should be used in a responsible, ecologically-minded manner. At the Copalis experimental site, there are nesting locations in protected ledges, as well as likely former nesting areas on the tops of islands and islets (e.g., Erin). We suggest that should Phase II go forward, a first step would be deployment of decoys in ledge/crevice locations.

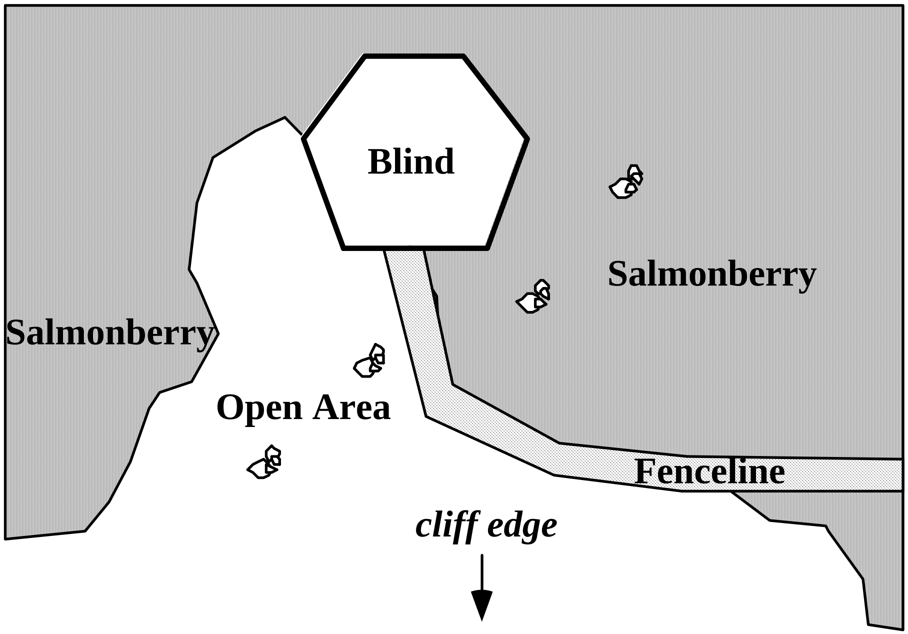
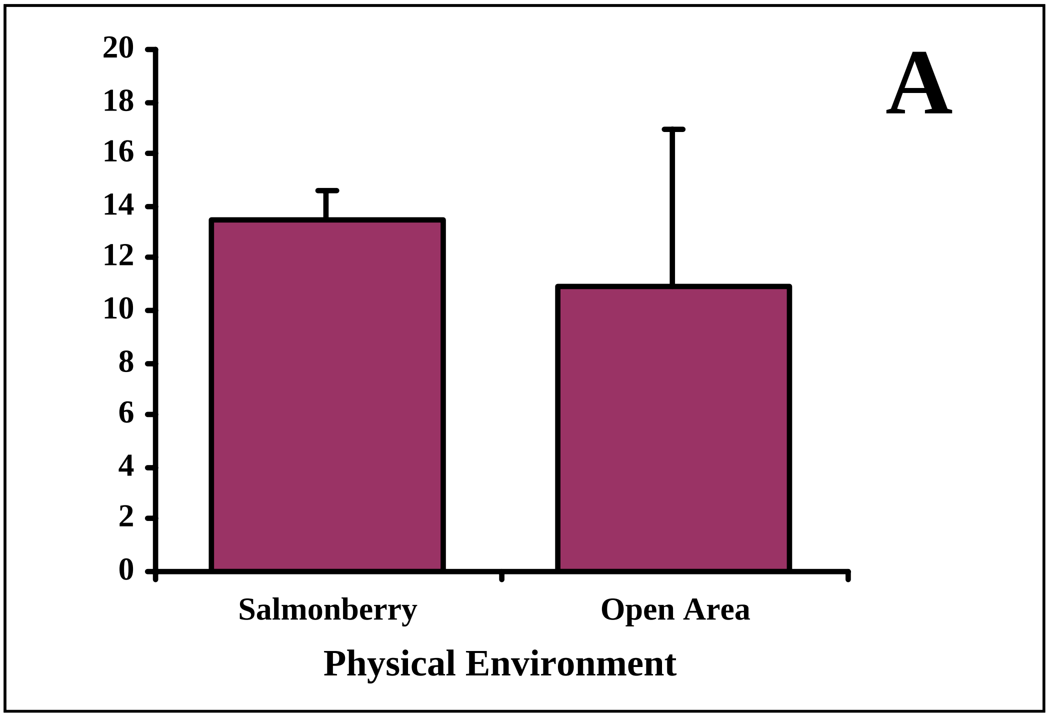


Figure A1. Schematic diagram of decoy and artificial vegetation placement, relative to extant salmonberry and existing blind location. Note that the line of decoys forms a continuum, from most risky (farthest into open area and from reinforced salmonberry) to most safe (farthest into the live salmonberry).



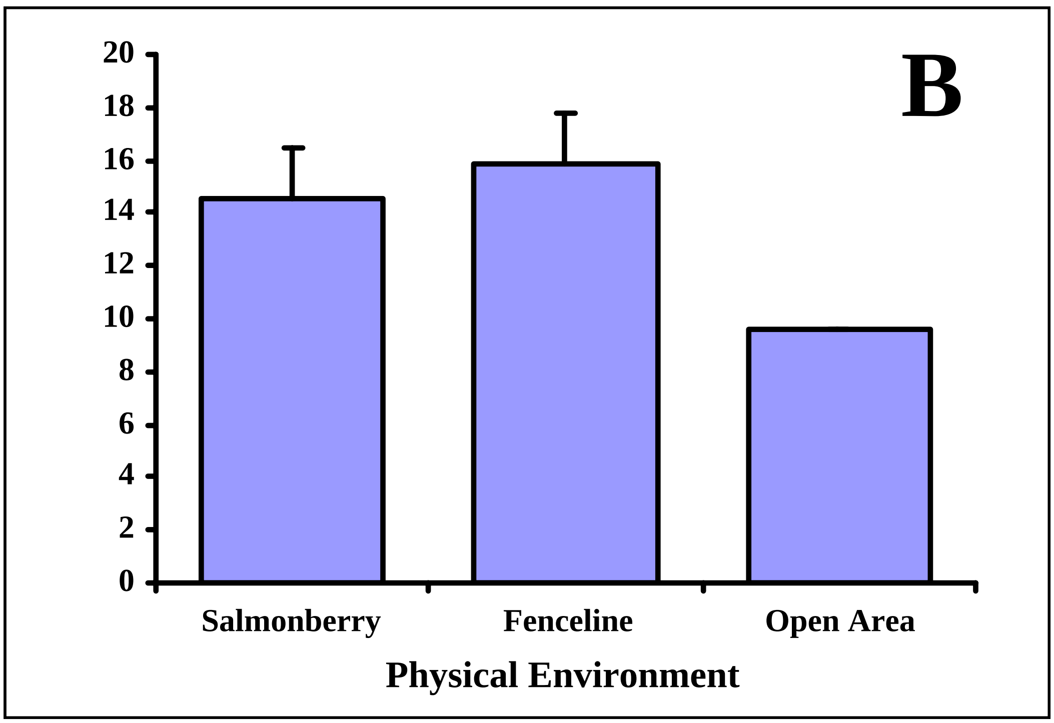
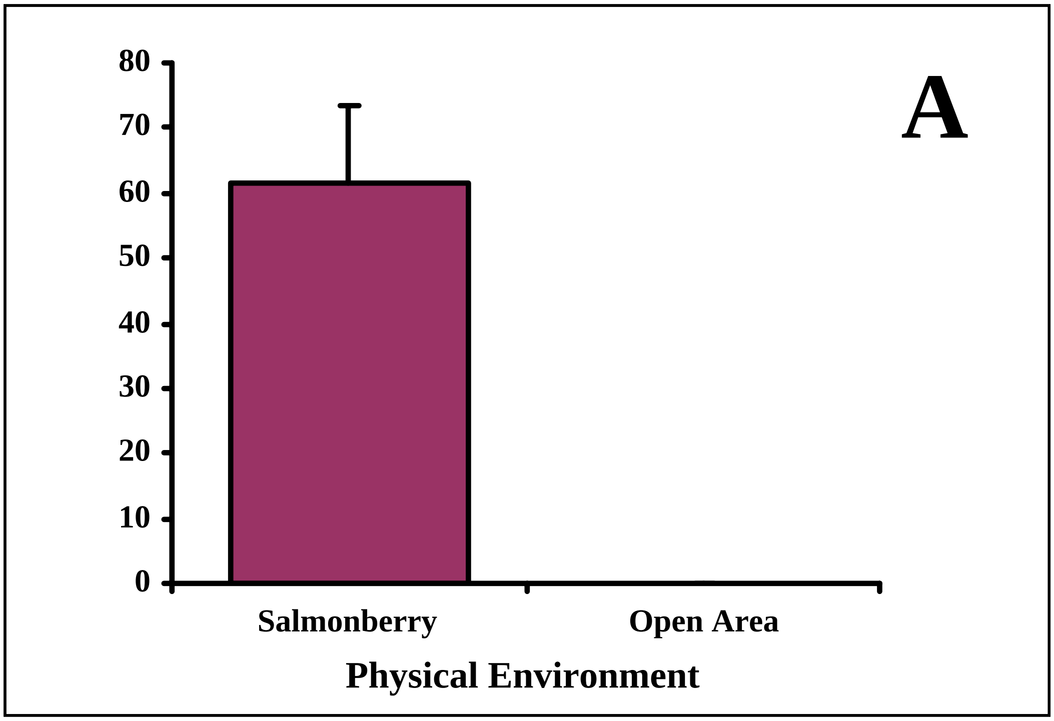


Figure A2. Effect of physical and social manipulation on Common Murre nesting density. A. Average density of murres nesting within a 50cm radius of decoys as a function of physical environment. B. Average density of murres nesting within 1m diameter plots, exclusive of decoys, as a function of physical environment.



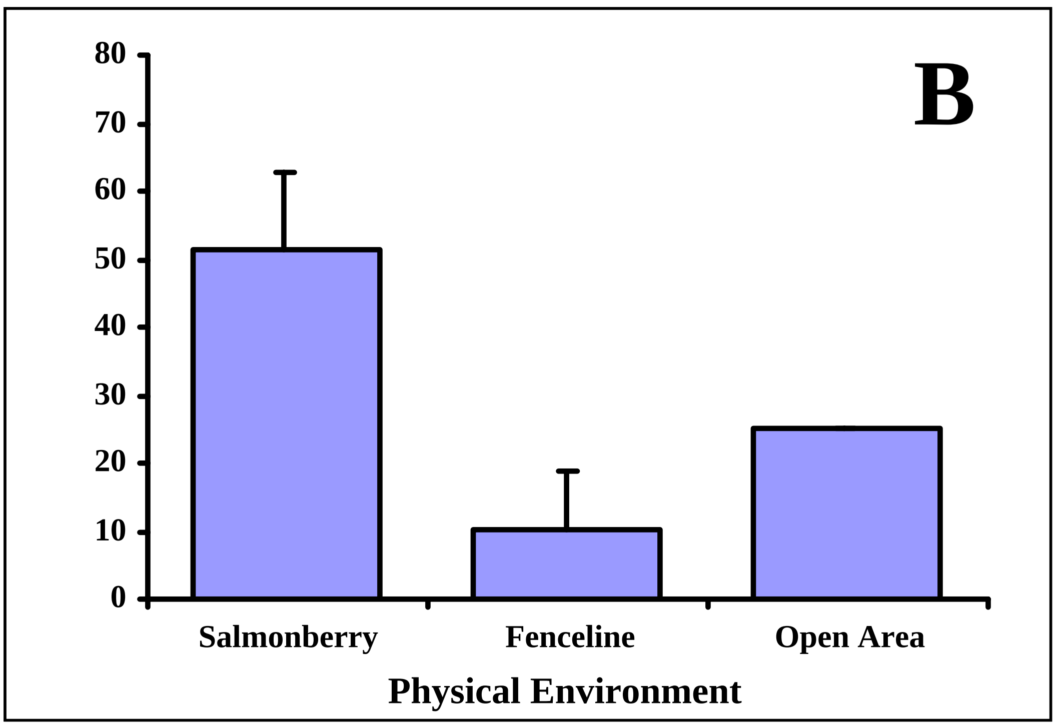


Figure A3. Effect of physical and social manipulation on Common Murre reproductive success. A. Average density of murres nesting within a 50cm radius of decoys as a function of physical environment. B. Average density of murres nesting within 1m diameter plots, exclusive of decoys, as a function of physical environment.

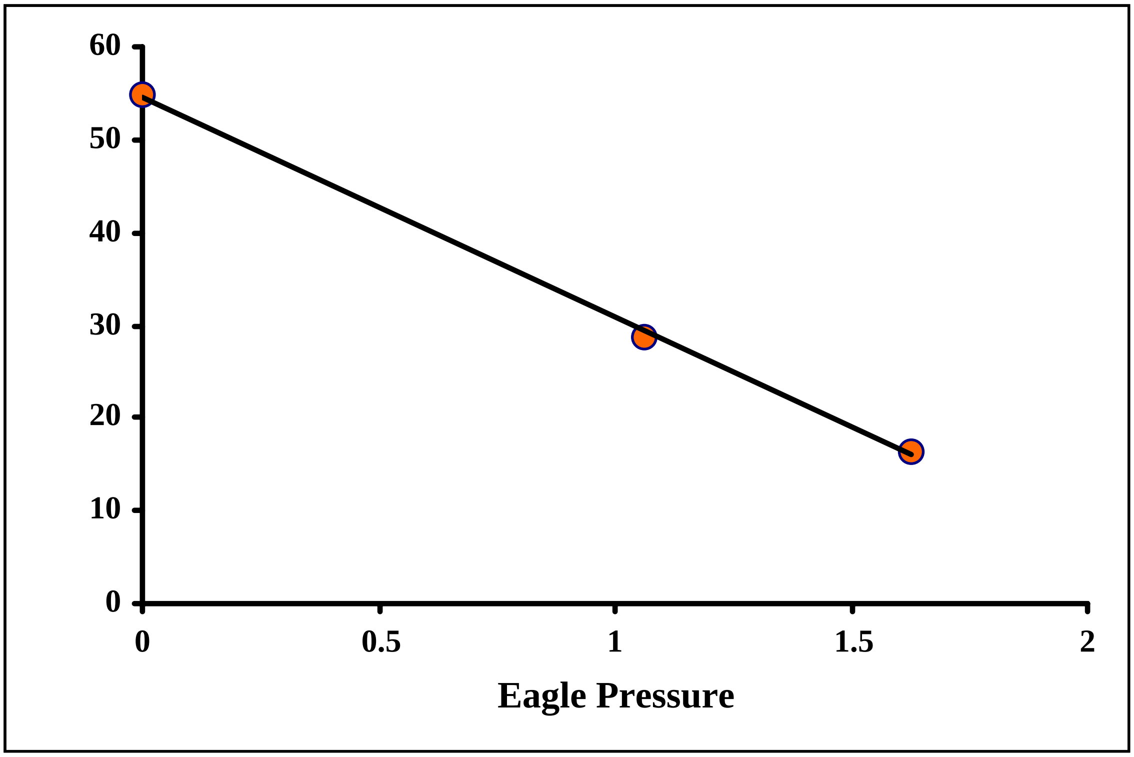


Figure A4. The effect of eagle pressure (measured as equally weighted percent time eagles were seen and eagle kills) on murre nesting success (measured as percent of pairs fledging a chick).